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Natural Resource Program Center

DRAFT Integrated Cave Entrance Community and Cave Environment Long-Term Monitoring Protocol

Version 1.0 Klamath Inventory and Monitoring Network

Natural Resource Report NPS/KLMN/NRR—2010/XXX

ON THE COVER
Caldwell Ice Cave, Lava Beds National Monument
Photograph by: Dr. Jean K. Krejca

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Revision History Log

Previous Version	Revision Date	Author	Changes Made	Reason for Change	New Version

It will be necessary to periodically revise both the protocol narrative and associated Standard Operating Procedures (SOPs). Documentation of revisions is critical to identify consistency or changes in data collection and management procedures. The format of a protocol narrative complemented by SOPs simplifies the revision process. Because the narrative is a general overview of the planning, sampling, and data management methodologies, it will only require revisions if large changes are made to the Protocol. The SOPs, in contrast, are very specific and may require more frequent minor revisions. Instructions for making protocol revisions are in SOP #1: Protocol Revision Process. A revision log is included on the cover page of this narrative and at the beginning of each SOP to track what changes were made and why. In addition, SOP revisions will require updating of the version numbers and the names of each document that was changed.

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Abstract

This long-term cave monitoring protocol was created according to NPS and Klamath Inventory and Monitoring Network (KLMN) guidance and standards. It concerns two parks, Lava Beds National Monument (LABE) and Oregon Caves National Monument (ORCA), and provides the rationale and methods for monitoring cave climate; ice and water levels; human visitation; coverage of ferns, mosses, and lichen; bat colonies; scat deposition; and invertebrate communities in caves. The protocol consists of a descriptive narrative, Standard Operating Procedures (SOPs) for various tasks, and appendices of relevant information. These procedures were designed for long-term use by each park so that data could be collected consistently and provide defensible results for management of park resources, public interpretation, and scientific research.

Acknowledgements

The LABE resource managers, David Larson and Shane Fryer, and the ORCA resource managers, John Roth and Elizabeth Hale, contributed greatly to the protocols. Other contributors included Shawn Thomas (ORCA), Jason Mateljak (LABE), Dennis Odion (Southern Oregon University), Elizabeth (Bess) Perry (KLMN), and Eric Dinger (KLMN). We would also like to the Kathi Irvine (Montana State University) for her statistical support.

The cave resource monitoring meeting in Denver (November 2008) led by Denis Davis, Steve Fancy, and Dale Pate was extremely helpful for maintaining a national perspective on cave resource monitoring objectives.

1.0 Background and Objectives

1.1 Introduction

This protocol narrative outlines the rationale, sampling design, and methods for monitoring cave environments in the Klamath Inventory and Monitoring Network (KLMN or the Network) of the National Park Service (NPS). It has been prepared in accordance with NPS guidance and standards (Oakley et al. 2003; Mohren 2007; Sarr et al. 2007). The KLMN includes six parks, two of which have significant cave resources and are the subject of this document: Lava Beds National Monument (LABE) and Oregon Caves National Monument (ORCA). These two parks are located in southern Oregon and northern California and have caves with endemic species, flowing underground streams, permanent ice, cultural artifacts, and many other special features.

This monitoring project is designed to track in-cave changes of four abiotic and four biotic parameters deemed by panels of experts and park staff to be most relevant to established inventory and monitoring goals for the Network (Sarr et al. 2007). At least 14 specific criteria were used to rank these parameters, including cost-effectiveness, ecological significance, and potential use as a management tool. Tracking changes in these selected parameters will provide many benefits, including the abilities to discern the differences of natural vs. anthropogenic variation, to compare changes in these parks with the 83 other cave parks in the nation to examine broad-scale vs. local changes, to advise managers about strategies they may adopt to improve cave conditions, to provide a baseline of a relatively protected area that can be compared spatially and temporally within and outside of park boundaries, to create a means for park personnel to regularly evaluate cave conditions and potentially recognize changes or research needs, and to provide material for outreach activities.

Data collection methods for biotic and abiotic cave parameters vary between management plans and monitoring activities at different caves across the country. This protocol follows some existing methods to the extent they are applicable to ORCA and LABE (e.g., invertebrate searches described by Helf et al. 2005), or where continuing previous methods used in the KLMN allows comparisons with historic monitoring (e.g., bat monitoring at LABE and ORCA). In some cases, no adequate methods existed to date (e.g., scat monitoring to track use of cave entrances by birds and small mammals) and so they were developed using literature reviews and surveys of experts.

Some sampling approaches vary slightly at the two parks due to differences in size, quantity of caves, genesis (lava tube vs. limestone dissolution), and visitation levels. However, the data collection, recording, and analysis are standardized to allow spatial and temporal comparisons between these caves and parks and to provide the potential to make comparisons among the approximately 83 other parks in the NPS known to contain caves if they chose to emulate these methods.

1.2. Monitoring History

Monitoring histories for LABE and ORCA were prepared by park personnel in the preparation of this protocol and are presented here to provide some background on previous monitoring efforts.

1.2.1 History of Monitoring at Lava Beds

Bats: The Monument currently protects 14 documented species of bats. Of these, significant maternal roosts of Townsend's Big-eared bats (*Corynorhinus townsendii*), Pallid bats (*Antrozous pallidus*), and Brazilian free-tailed bats (*Tadarida brasiliensis*) have been monitored. Additionally, limited monitoring has confirmed colonies of Cave Myotis (*Myotis velifer*) and Small-footed Myotis (*Myotis ciliolabrum*) in the Monument. Bats are critical components in the ecology of caves as they transport nutrients into the system and generate visitor interest. The park first began documenting bat use in caves in 1962, and has conducted intensive monitoring since 1985.

Dr. Stephen Cross of Southern Oregon University in Ashland, Oregon, completed an analysis of the Monument's Brazilian Free-tailed bat population in 1988. He established a protocol that monitored the exit flight, behavior, and associated environmental influences on a yearly basis during the maternal season. In addition, Dr. Cross did guano deposit core sampling and bat corpse analysis testing for pesticide contamination and found evidence of pesticide and contaminant presence (Cross 1989). Between 1988 and 2009, park staff have continued photographic monitoring as per Cross's methods of select outflight emergences during the summer maternal season (mid June - mid September); this monitoring has revealed annual fluctuations in the population (Fuhrmann 1997; Knipps 1998; Roundtree 2000; Dunne 2002; Purinton 2004; Pleszewski 2005; Mateljak et al. 2006).

Townsend's Big-eared bat monitoring and management at LABE has varied across time. Before 1988, there was no active management and monitoring did not exist beyond occasional observations made by visitors and staff. Between 1988 and 1995, summer interns began to assess colony locations and sizes and established a database for bat observations. Cave closures related to bat presence began in 1993. In 1996, a seasonal "bat specialist" was hired to create survey and monitoring protocols and devote an entire field season to bat management projects. Between 1997 and 1999, the bat management program was expanded to include an active survey and monitoring program (focusing on population dynamics), environmental monitoring of bat roosts, and surveys of night time flying insects. Cave closures were enacted to protect newly identified roosts and, in some cases, surveillance equipment was installed to detect unauthorized human access. Cave gating projects were also initiated and foraging surveys were completed in 1997 using radiotelemetry. By 2008, three Townsend's Big-eared bat maternity colonies were known in the park, along with the largest hibernaculum site in California (650+/- bats), and maternity season outflight counts were regularly conducted (e.g., Dunne 2002).

Ice Resources: Since 1990, resource management volunteers have monitored 10 caves that have historically contained substantial ice resources. As of 2007, the park had observed the dramatic loss of ice in seven of the 10 monitored caves, with the near total loss of ice in four caves. A 0.5°C degree rise in the mean monthly low surface temperature and a near $1.5^{+\circ}$C rise in the mean monthly high surface temperatures seen over the past 60 years is a suspected cause for this ice loss.

In an attempt to quantify and monitor ice loss, an Ice Level Study was initiated in 1988 by William Devereaux (Devereaux 2009). The study consisted of measuring the distance from a permanent station down to the surface of an ice floor. With the exception of Merrill Ice Cave, which had a large breach open in the ice floor, most ice pools graded up and down with accretion and ablation. This study has allowed the Monument to monitor ice levels from a 0 datum (the initial measurement) and gives a reasonable illustration of loss or gain at study sites.

Visitation: In 2008, visitation was monitored in 11 caves by electronic trail counters and in 18 other caves by voluntary registers. It is expected that by spring 2010 all pressure plate counters will be replaced with TRAFx infra-red data logging counters (Appendix D-F).

Photo Monitoring: Cave Research Foundation members Bill and Perri Frantz, with the support of LABE, developed a photomonitoring protocol for 16 front and backcountry caves, which included 37 monitoring sites. Monitoring has the potential to document speleogen breakage, litter accumulation, ice level variability, and structural impacts. Between 1990 and 2008, the protocol was completed five times. Starting in 2008, the Frantz's have begun to assess images and officially update monitoring protocols for digital cameras (Frantz and Frantz 2009).

Impact Inventory: In 2008, the first impact inventory of the Monument's front country caves was completed (Rogers 2008). This inventory gives resource staff a baseline and planning tool for future restorative efforts. The inventory is proposed to be developed into an impact monitoring protocol.

1.2.2 Monitoring History in ORCA

Oregon Caves has a longer period of cave inventory and monitoring than Lave Beds, and a wider array of parameters measured, but most efforts have been sporadic or of relatively recent duration. Temperature and humidity in various parts of Oregon Caves was initially recorded during the last major exploration and survey in the late 1960s and early 1970s (Halliday 1963; Eide 1972; Knutson 1973; Sims 1980; Aley and Aley 1987a, b; Aley 1988).

Hygrothermographs were deployed in the cave in 1988-1989 to record temperature and relative humidity to assess whether additional doors in constructed tunnels were needed for airflow restoration; the results indicated that additional doors were not needed. HOBO data loggers have been recording temperature and humidity throughout the cave since 2005; data show inner cave temperatures range from 6.6-7.2ºC. Humidity data from the HOBOs has been unreliable, especially at the high humidity levels common in caves. A carbon dioxide meter has been used to measure monthly carbon dioxide levels throughout the cave since 2007. A doctoral dissertation was completed by an Oregon State University student (Ersek 2008) that provided a high resolution, long-term cave climate baseline that used oxygen isotopes from a stalagmite as temperature proxies.

In 1991, a weir was placed on the subterranean River Styx, close to where it exits the cave and becomes Lower Cave Creek. Monthly readings were made during 1992. In 2007, a WaterLOG pressure transducer and a staff gauge were installed about 15 m upstream to record stream depth and water temperature. Starting in 2008, the water level in seasonal cave pools has been measured. Ice is known to form in the cave entrance and Watson's Grotto in winter, but it has not previously been monitored.

Drip-water infiltration at one to three points in the cave has been recorded by tipping buckets and data loggers since 1998 (Salinas 1999a, 1999b, 2000, 2001, 2002a, 2002b, 2004). A 1992-1993 monthly synoptic baseline recorded major ions, pH, conductivity, dissolved carbon, and temperature of various types of cave and surface waters. Dissolved zinc indicated leaching of galvanized steel handrails, which were subsequently replaced by dense fiberglass and stainless steel (Miller et al. 1998, Schubert 2007). A 1994 study suggested that a little leaching of hydrocarbons from asphalt trails occurred at that time (John Roth, personal communication). The asphalt was subsequently replaced by concrete and fiberglass. Water quality measurements by the US Geological Survey (USGS) in 1997 (Miller et al. 1998) and a park contractor in 2003-2004 (Salinas 1999a, 1999b, 2000, 2001, 2002a, 2002b, 2004) also included phosphates, nitrates, and similar dissolved substances (Currens et al. 2005).

Starting in 2007, blocks of marble were strategically placed in the cave water bodies (drip, pool, and stream areas) and have been dried and weighed on a monthly basis to determine dissolution rates. The pH and conductivity of the associated cave waters are being measured to see if they match earlier calcite solubility indices based on the 1992-1993 water chemistry.

Significant lint build-up has been observed in the cave, but attempts to measure dust deposition have been confounded by wood rat interference. Lint collected from cave clean-ups has been weighed and recorded since 2007. Cave and park visitation records go back as far as 1910, with peak visitation occuring in the 1970s (Hoger et al. 2003).

In the early 1990s, a room-by-room inventory of most of the cave established baselines for speleothem breakage and direction of airflow. An inventory of broken speleothems was conducted in 1991 and 1995, and broken formations were marked with a grease pencil to monitor vandalism. However, vandalism rates could not be determined in 2006, due to lack of documentation during the initial inventory. Also, cave water washed off some of the grease pencil markings. In 2007, efforts were made to re-mark broken formations with UV inks and mixtures of clear paint with UV powders, but those substances underperformed in certain very wet and very dry parts of the cave and many of the marks dried white instead of clear. Fixed-point photomonitoring stations were established in 2003 and will add some data on breakage rates, but there are not enough sampling points for them to be very representative. Sites along the tour route are photomonitored every 3 years (Yates 2007).

The room-by-room inventory also noted several biotic parameters, including visible macroinvertebrates, coverage of wall microbes and possibly correlated deposits like moonmilk, limestone crusts, and vermiculations.

The results of bat tagging in the late 1950s showed high fidelity of cave exit and entrance flight patterns at Oregon Caves (Cross 1976, 1977, 1986, 1987). Recaptures from harp traps showed fairly stable populations of bats using the cave from the early 1970s into the early 1990s (Cross 1997). A study in 1995 showed a substantial decline, originally attributed to changes in airflow caused by restoration of airflow via air restrictors placed in tunnels blasted out in the 1930s (Cross 1997). However, a study in 2002 found the decline appeared to be a sampling artifact due to changes in entrance/exit usage (Cross and Waldien 2002). Radio transmitters in the late 1970s and Anabat II bat detectors and mist netting in the early 2000s indicate that most bats do not spend much time at the Monument once they leave the cave (Cross 1976, 1977, 1986, 1987, 1989, 1997; Whiteman 1997; Cross and Waldien 2002 and 2003).

Other systematic taxa surveys involved the coverage and taxonomic identification of lampenflora (mostly diatoms and cyanobacteria) near electric lights in the mid and late 1980s, respectively (Aley and Aley 1987a, b; Aley 1988; Aley 1997). Control by bleach was initiated and wall coverage was monitored thereafter. Reduced lighting and supplemental use of hydrogen peroxide further reduced the impacts of these invasive species by the mid 1990s.

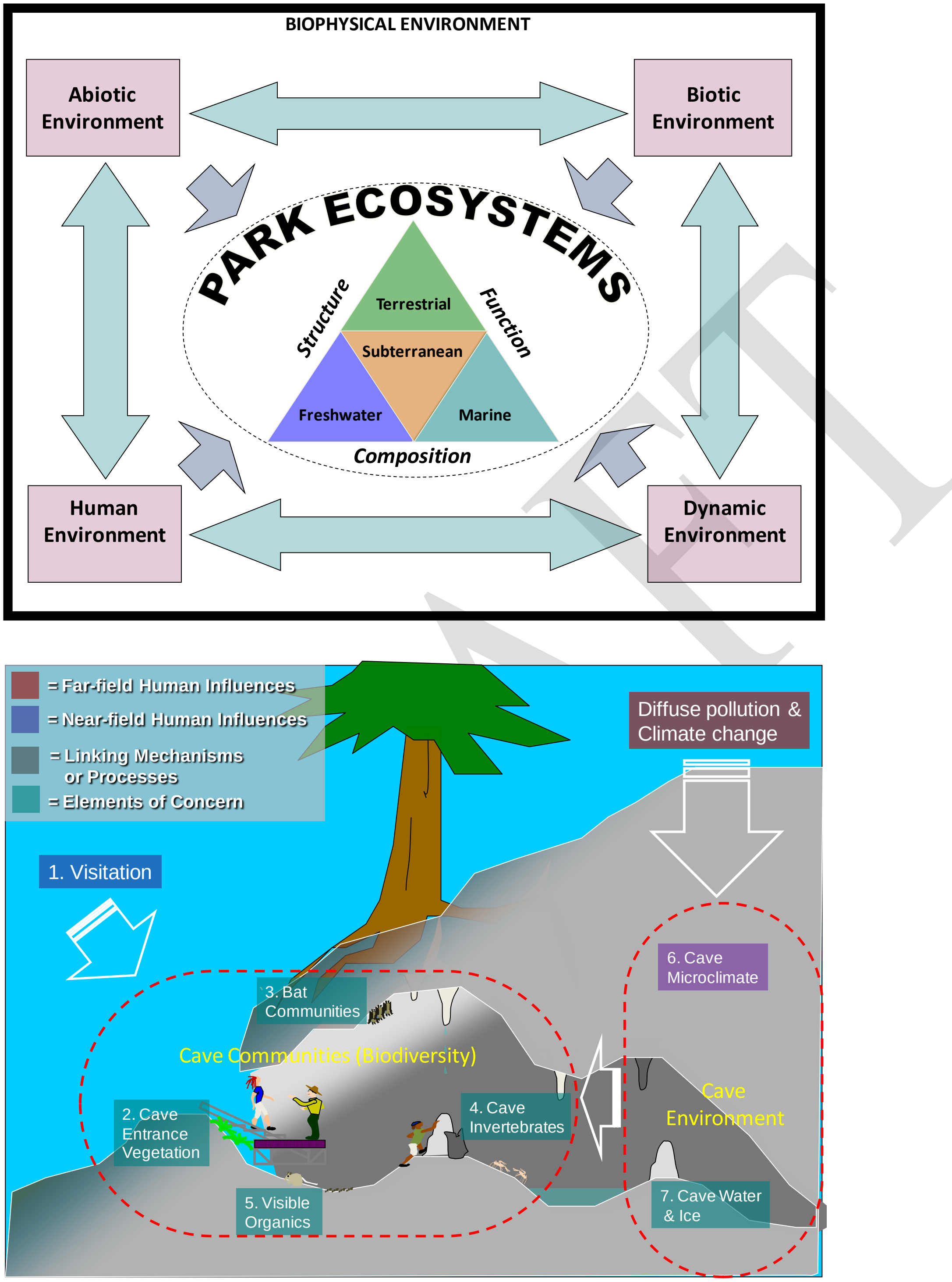
In the early 1990s, pit traps in Oregon Caves sampled each month for 15 months collected over 100 species of macroinvertebrates (Crawford 1994, 1996). They also established that invasive species and/or other human-introduced organics like clothing lint were increasing at and near the paved trail. Synoptic counts along the tour path of bats and large macroinvertebrates began in 2001. A macroinvertebrate biodiversity study with non-lethal passive pit traps, along with "Critter Counts" (Hale 2007), was started in 2007. Analysis of the first series of data collection was performed by Iskali (2008) to investigate whether removing human-caused organics helps restore the Shannon-Weaver biodiversity index of richness and evenness.

A 1991 dissolved oxygen study suggested that the start of the fall rains moved dissolved organics into cave pools. The pools then showed increased microbial activity before slowing from dilution, recovering as dilution decreased, and then slowly declining in activity as summer progressed and less water and organics entered the cave (Bratvold 1995). Comparison with cave microbial wall coverage, biofilms, and dissolved organic inputs suggested that fewer dissolved organics entered Oregon Caves compared to many Eastern US caves. This presumably may be due to greater summer drought and possibly to more oxidation during longer soil storage at Oregon Caves. Cave fungi and bacteria were sampled, cultured, and identified, generally down to genus level, in 2003 and 2004 (Carpenter 2003 and 2004). DNA results from fungi, archaea, and bacteria (both chemo-organotrophs and chemotrophs) were registered in GenBank. These data suggested that trail effects did not extend to such taxa along less traveled routes in the cave (Fuller 2006).

1.3. Conceptual Basis for Selecting Cave Environments and Entrance Communities

Sarr et al. (2007) and Odion et al. (2005) describe the process by which cave environments and cave entrance communities became selected as two of the top ten vital signs to be monitored in the Network. The process involved creating a large set of candidate monitoring subjects that panels of experts ranked based on five management criteria (i.e., provides an early warning of loss of ecological integrity that can be addressed through management actions) and five ecological criteria (i.e., addresses changes to ecosystem structure, composition, and function that may occur). In the second step, experts considered the legal/policy mandate and cost/feasibility of candidates and chose cave environments and entrance communities as important vital signs to be monitored.

Within the parks of the Klamath Network, Subterranean Ecosystems were considered among the four essential ecosystem domains in the Klamath Network parks for which long-term monitoring information was needed (Figure 1a). Cave entrance communities and cave environmental conditions were chosen as the best vital signs for the Subterranean Domain (Sarr et al. 2007). Figure 1b illustrates the relationships between near- and far-field human influences and the focal communities and ecosystem parameters selected for monitoring.



a.

b.

Figure 1 a, b. (a) The biophysical environment and ecosystem domains of the Klamath Network parks. (b) A conceptual model of a cave ecosystem illustrating near- and far-field human influences and selected vital signs.

1.4 Vital Signs Monitoring Objectives

The primary monitoring objectives are:

1. *Monitor the status and trends of human impacts.* The purpose is to help discern whether visitors are affecting the observed variation of measured parameters, and to cue resource managers to respond and limit these negative effects.

2. *Monitor the status and trends of focal species and communities.* This involves various techniques for measuring Townsend's Big-eared bats *(Corynorhinus townsendii)*, trogloxenes, invertebrates, and flora. The goal is to establish a baseline of variability in the first 8-12 years and, ultimately, evaluate long-term trends.

3. *Monitor the status and trends of groundwater and ice resources.* Measuring pool levels and ice surfaces will quantify the loss or gain of water and ice, valuable resources in themselves but also linked to large-scale climate change (e.g., warming and drying trends) and cave-specific changes (e.g., changes in entrance morphology and gates impact airflow through caves). The goal is to establish a baseline of variability in the first 8-12 years and ultimately, evaluate long-term trends.

4. *Monitor the status and trends of cave climate*. Stable temperatures and high humidity are hallmark characteristics of caves and are inherently worthwhile to monitor. In addition, these parameters define the habitat for rare and endemic fauna. The goal is to establish a baseline of variability in the first 8-12 years and, ultimately, evaluate long-term trends.

5. *Analyze trends in each parameter across monitored caves and use this dataset to make inferences across all caves.* Analyses will be performed that are specific to each parameter across the sampling time frame. This dataset could be used to assist with long-term goals such as establishing links between variables (e.g., climate and ice, or water and invertebrates) and hypothesize causal relationships.

Recognizing the limited funding and staffing resources available for long-term monitoring, the KLMN cave monitoring protocol will address these objectives by monitoring four abiotic and four biotic parameters that target important resources or potential sources of impact and disturbance. Monitoring should detect significant changes in valued resources, including increases in disturbance or shifts from historic levels. As parameters covary, potential causal relationships can be examined.

2.0 Parameter Selection and Sampling Design

The parameters were selected in consultation with park and I&M professionals to most effectively address the monitoring objectives. Spatial sampling design was created to ensure field data are statistically robust and could be collected safely and feasibly by seasonal field crews. The sampling focuses on four abiotic and four biotic parameters, whose sampling populations vary throughout the sampling frame.

2.1 Rational for Selection of Parameters

This list of abiotic and biotic parameters was selected by staff from the parks, with input from monitoring specialists in the KLMN and from cave scientists at Zara Environmental in a series of scoping meetings from 2007-2009. The original list of parameters was then refined based on a pilot study (Thomas 2010). The cave entrance community and cave environment vital signs are expected to be sampled and analyzed together. Hereafter, we refer to the selected parameters for these vital signs as simply abiotic and biotic parameters. The following parameters will be monitored under this protocol:

2.1.1 Abiotic Parameters

1. Cave Meteorology: Using data loggers, measure relative humidity and temperature (SOP #5: Climate).
2. Ice: Create a record of ice levels using photographs taken from established stations, as well as surveys from fixed points of the height and extent of ice surfaces (SOP #6: Ice)
3. Water Levels: Create a record of water levels using staff gauges (SOP #4: Water).
4. Human Visitation: Record the number of human visitors to each cave using ticket sale records, infrared counters, and visitor logs (SOP #7: Visitation).

2.1.2 Biotic Parameters

5. Cave Entrance Vegetation: Use line-transect, point intercept method to estimate cover by group and growth form within group (i.e., shrub, fern, herb, or graminoid, for vascular plants) (SOP #9: Cave Entrance Vegetation).
6. Bat Populations: Using direct observation and sampling of known winter hibernacula, measure spatial distributions and relative abundance of bats (SOP #8: Bats).
7. Scat and Organic Matter: Record the number of scats and visible organic matter using timed visual searches (SOP #10: Scat and Visible Organics).
8. Cave Invertebrates: Using bait stations, monitor communities of cave invertebrates (SOP #11: Invertebrates).

These parameters will be measured over different seasons though a partnership between the two parks and the Klamath Network (Appendix H: Memorandum of Agreement). During even years, the KLMN will monitor scat, invertebrates, and cave entrance vegetation. LABE and ORCA staff will monitor visitation, bats, water, and ice, and periodically download climate data within their respective parks every year (see sampling frequency section for more details).

2.1.3 Alternative Parameters Considered

During the initial cave scoping meetings that evaluated potential parameters to measure, hydrology and water quality ranked very high. It was determined that existing KLMN vital signs monitoring of water quality and aquatic communities (including temperature, chemistry, flow, aquatic macroinvertebrates, and pollutant loads) could be a surrogate for cave-specific methods. Cave-specific methods (e.g., constant monitoring or flood pulse monitoring), while ideal given the complex and flashy nature of contaminant flow through karst (White 1988), were judged too labor intensive for this protocol. They would require an extensive pilot study to determine the best method of implementation and, given the current state of knowledge of these systems, this work is more closely aligned to research objectives than monitoring.

Other high-ranking abiotic parameters include impacts to floors (compaction, disturbance) and broken formations as measures of visitation impacts. Impacts to floors are considered important to monitor since trampling around entrances destroys plant populations and deep in caves eliminates microhabitats (e.g., spaces underneath rocks and interstitial voids) for cave invertebrates. We determined that the entrance flora populations will be captured in biotic parameter number 5 above. Deep cave microhabitat disturbances fell lower in ranking because of the difficulty to measure and lack of standard procedures for measurement, as well as the lack of literature indicating what threshold of impact needs to be detected to be relevant to species' biology. ORCA staff indicated their use of several methods to monitor formation breakage, including photograph stations and paint dot inventories, but these had disadvantages that prevented successful measurement. Previous efforts have demonstrated difficulty in permanently marking the features due to moisture. In some cases, it has been difficult to determine what was natural and what was broken; it was suggested that this was actually a management issue and therefore not suited to this monitoring protocol (section 1.2.2: Monitoring History in ORCA).

Monitoring dust and lint accumulation was given serious consideration and field tested. However, during the pilot study, it became apparent that any surface placed to collect dust and lint quickly became wet in the hyperhumid cave environment, preventing accurate measurements or monitoring (Thomas 2010).

An additional high-ranking biotic parameter considered for measurement was microbes. Microbial diversity of caves is known to be significant both in terms of globally rare species, colony fragility, microbe position at the base of the food chain, and universal distribution on the planet (e.g., Arrigo 2005, Bond-Lamberty and Thomson 2010). Direct biodiversity measurement is done via specialized methods such as genetic analysis; we determined that an indirect measure of microbial activity, Biological Oxygen Demand of pools and soil, is more efficient and better fit our evaluation criteria. This parameter, however, ranked lower than the eight identified above.

2.1.4 Rationale and Sampling Design Considerations for Selected Parameters

Climate Monitoring: Meteorology is important to measure, along with other parameters, because its effects are wide ranging and alterations in climate patterns can set off a cascade of other changes. Temperature and humidity are recorded every hour at all caves and the level of detectible significant change will depend on the natural variation within caves (Appendix B: Results of Power Analyses). HOBOs can detect a +/- 0.18ºC change in temperature, and a +/- 2.5% change in relative humidity, although this level of resolution might not be possible at extremely high humidity. While most data recording devices can now store enough information that they need only be checked at very infrequent intervals, data collection is more frequent to minimize losses and discover problems that might interfere with data analysis. The equipment and methods for monitoring climate are detailed in SOP #5: Climate.

Water and Ice Monitoring: Water and ice levels affect biotic and abiotic systems in caves, plus ice deposits and water availability may be threatened by rising mean temperatures. Some caves have permanent ice or water features, while others experience seasonal melting/freezing. It is important to monitor ice in caves because the energy required to melt ice, or conversely, the energy liberated when water freezes, serves to buffer cave temperatures. With less ice to melt in the summer, the cave temperature rises to a higher temperature, and more remote or deeper ice can melt, creating a positive feedback loop. We evaluated only simple, easily implemented measurement techniques, including surveys from fixed stations and photograph monitoring. They are described in SOP #4: Water and SOP #6: Ice and call for measurements from established points. Ice measurements will include both the elevation of the ice surface and the surface area. Water measurements will be for the water elevation.

Visitation Monitoring: Human visitation can have major impacts on caves; in parks where hundreds or thousands of visitors traverse small areas in caves, visitation likely creates the largest impacts. Monitoring visitation is critical for detecting correlations between visitation levels and other parameters. If alterations in some parameters are linked to human visitation, those parameters may be protected by adaptive management (e.g., changing trail routes). Methods described in SOP #7: Visitation detail the equipment and methods needed to count the number of human visitors to each cave. Changes in visitation impacts are largely assumed to track changes in the overall number of visitors, but even a single additional visitor can be detected using these methods.

Cave Entrance Vegetation Monitoring: Cave entrances provide unique conditions for plant life. At LABE, entrances form islands of habitat for ferns and lichen. Some species in and around LABE cave entrances are locally rare and disjunct from the rest of their established ranges (Dr. Steve Jessup, personal communication). They compose a unique component of the Monument’s biodiversity and the importance of these communities was recognized and described in the vital signs scoping process of the Klamath Inventory and Monitoring Program (Sarr et al. 2007).

Some caves draw human visitors who can impact the vegetation around entrances. Impacts at these sites can likely be minimized through appropriate planning and management, and monitoring will provide feedback to trigger and guide those processes. Research presented in a poster by T. Vanover, S. Schwab, and R. O’Quinn at the Department of Biology at Eastern Washington University suggested that visitation can reduce cover and species richness of lichen near cave entrances in LABE. Such visitor use impacts likely affect all vegetation types. Little is known about the role of vascular plants, bryophytes, and lichen in cave entrance ecology, but given that the cave entrance biota are unique but vulnerable to human impacts, it was deemed important to monitor.

SOP #9: Cave Entrance Vegetation describes the equipment, methods, timing, and location of monitoring for cave entrance communities. Klamath Network vegetation ecologists discussed alternative methodologies and chose the point intercept method described in SOP #9 to rapidly estimate cover by group and growth form within group (i.e., shrub, fern, herb, or graminoid, for vascular plants). This method will allow a crew with little training in vegetation monitoring techniques or identification to quickly assess vegetation cover at cave entrances. This method, in addition to being easy to employ, is highly effective for monitoring changes in percent cover (Elzinga et al. 2001). In addition to this effort, the KLMN will also be implementing a surface vegetation monitoring protocol throughout both parks (Odion et al. 2010) that should provide important context for the cave entrance findings.

Bat Monitoring: Bats are a high profile park resource that generate visitor interest and are an important part of cave ecosystems. Many methods exist to monitor bats, including but not limited to visual counts, acoustic recordings, emergence counts, disturbance counts, mark-recapture, mist netting, still and motion picture photography, extrapolation of numbers based on density and area covered, guano deposition, and infrared photography and videography. The USGS (2003) provides a good overview of available techniques. We chose in-cave visual counts in order to have consistency with existing protocols in the parks; minimize special training, techniques, and analysis; and avoid having to handle bats for researcher safety.

Monitoring bats is described in SOP #8: Bats and will be implemented during the winter hibernation season at the parks. This protocol focuses on winter hibernation counts of a subset of caves with a known Townsend's Big-eared bat (*Corynorhinus townsendii*) population and the documentation of incidental observations of all bats. Combining bat monitoring with climate and invertebrate monitoring may also deepen our understanding of the interrelatedness of these parameters.

Scat and Visible Organics Monitoring: Scat deposition, mostly from rodents but also from other mammals and birds, will be monitored because scat represents a substantial energy source in caves and demonstrates small mammal use of caves. The timed area searches used to detect scat are fairly simple, requiring minimal training or equipment, and provide valuable information on the consistency and amount of nutrient inflows that support cave communities. Since management or visitor activities can affect rodent use of caves (through the construction of barriers; reduction of plant cover; or general disturbance from noise, light, and human presence), a monitoring program is necessary to detect changes and trigger management actions. Though rodents can be monitored using live traps (Mammoth Cave uses this method), this is labor and schedule intensive, while monitoring scat deposition is a simpler index to gauge rodent use in caves that is directly tied to nutrient flows. Methods are described in SOP #10: Scat and Visible Organics.

Invertebrate Monitoring: One truly unique aspect of park caves is the incidence of rare invertebrates found deep within them. Some are even park-endemic species and could be candidates for T&E listing because of their extremely restricted ranges. Cave invertebrates form decomposer communities that perform an important cave ecosystem function. Beyond their biological uniqueness or ecological function, they are interesting to visitors because of their bizarre morphology and "otherworldly" habitat. The low detectability of these species means that significant changes may take a long time to realize. However, monitoring can ultimately both detect changes and allow the resource staff to visit deep cave environments, increasing the likelihood that new species are encountered and range extensions are recorded. Additionally, the monitoring may uncover possible correlations with other monitored parameters such as climate or visitation.

Monitoring of rare, cryptic species is difficult. We considered detectability, distributional patterns throughout the cave, training of field staff, observer bias, replication and data analysis, but ultimately decided that bait stations were the most effective protocol given our constraints. The baited methods are similar to cave invertebrate monitoring in other parks (Helf et al. 2005), including methods already in use at ORCA. We anticipate that the visits to the bait stations will also give park staff the opportunity to visit the deep cave environment and become familiarized with the species there.

Aspects of this monitoring protocol will provide insight on varying spatial and temporal scales. Each cave is unique, and for several of the parameters we plan on monitoring, we will be able to examine status and trends at the cave scale. However, just as importantly, general status and trends across sites (reduced bat colony size or loss of permanent ice features) will be examined at the sampling frame scale. Furthermore, insights from monitoring can help guide management within a cave and provide a predictive element for assessing impacts at other caves. At the Network level, providing a coherent method for data collection, storage, and reporting will allow for broader analysis and retrospective investigations by future researchers. This well constructed monitoring program can document information whose value extends to other areas and grows with time.

2.2 Sampling Frame and Site Selection

The Sampling Frame section below defines the pool of possible sites, from which different methods were used to select exact sites for sampling. In many cases, each cave does not contain each parameter (e.g., bats or ice), and in some cases access, safety, and sensitivity are reasons to avoid repeat visits to certain caves.

2.2.1 Sampling Frame

2.2.1.1 Invertebrates, Scat, Climate, Visitation, and Vegetation Sampling Frame: At ORCA, monitoring will occur at the main cave called Oregon Cave and at a much smaller cave called Blind Leads Cave. Since all the major caves will be sampled at this park, our efforts will emphasize making probabilistic inferences across the cave habitat, rather than at the scale of an individual cave.

For LABE, the sampling frame of potential monitoring caves was developed by buffering the road network there to only include sites that are within 1 km of a road or trailhead. Once the buffer was applied, 421 caves (out of 744) remained. Then, any cave that was 1) less than 500 feet in length or 2) had not been previously inventoried was removed. The cave length criteria helped ensure all caves to be sampled have a deep, medium, and entrance zone. Once these filters were applied, a total of 59 caves remained, from which 31 caves were probabilistically selected.

2.2.1.2 Bat Sampling Frame: At LABE, the park staff had designated six bat caves that contain ~85% of the known population of Townsend's big-eared bats (*Corynorhinus townsendii*) in the park. Three additional bat caves were randomly selected during the site selection process described above. Bats, along with several of the other parameters, will be monitored at these sites on an annual basis. Results from these efforts will only be applied at these selected caves.

At ORCA, bat monitoring will occur in Oregon Cave, the only site known to have bats.

2.2.1.3 Ice and Water Sampling Frame: At LABE, the park staff designated five caves that have significant sources of ice. Monitoring will occur at these five caves (listed in Table 4). Any inferences from future analyses will apply only to these selected caves.

At ORCA, the park staff has designated five drip pools that will be monitored as part of this protocol. Any inferences from future analyses will apply only to these selected pools.

2.2.2 Site Selection
At ORCA, there are 23 designated sites inside Oregon Cave that are evenly distributed throughout the entirety of the cave (Figure 2). Most of these sites have pre-existing HOBO data loggers with records since 2005. It is our goal to keep monitoring these sites and to collect the data in a similar manner to ensure data continuity. The other small cave at ORCA, Blind Leads Cave, will have the same number and distribution of sites as the caves at LABE. Only two caves at ORCA were selected for monitoring, so that efforts could focus on Oregon Cave.

At LABE, Thomas (2010) determined that 31 caves could be sampled in a given field season based on logistics and funding available. A list of these caves can be found in Appendix C along with the cave codes that are used in this protocol to describe caves that contain sensitive resources. Once the sampling frame was selected, Generalized Random Tessellation Stratified (GRTS) methods were used to select the 31 caves out of the possible 59 discussed in Section 2.2.1.1 above. The GRTS selected the 31 desired caves and classified the remaining 28 as overflow caves to be used if one of the 31 selected was found to be unacceptable. This would ensure a spatially balanced sample of caves across the sampling frame where all parameters will be monitored.
In addition, the parks had designated six bat caves that contain ~85% of the known population of Townsend's big-eared bats (*Corynorhinus townsendii*) and five ice caves that contain a significant amount of ice as needing to be included in the selection of sites. These sites were included in the GRTS selection process described above. Those park-selected ice and bat caves that were not selected as part of the GRTS process were added to the list of caves to be monitored and a proportionate number of non-ice/bat caves from the GRTS selection were removed. This ensured we still had 31 caves to sample that included the six bat and five ice caves selected by the park.

Finally, for those selected caves that were questionable (access, cultural issues, zonation issues, etc.), the park staff visited the caves and made the determination of including or rejecting the cave for sampling. This resulted in removing three caves because they did not contain the three zones (Section 2.3) desired for sampling.

The end result was 31 caves, of which nine are designated bat caves (six preselected and three from the random GRTS draw), five are designated as ice caves, and 20 random caves (10 of which have known visitor use, three with a know bat population). Therefore, the final sample design was selected through a hybrid approach that emphasized randomization and spatial balance, but modified by subjectively adding 11 (approximately 1/3) caves to ensure we sampled the focal ice and bat resources adequately. Table 4 lists the caves and the various resources at those caves.

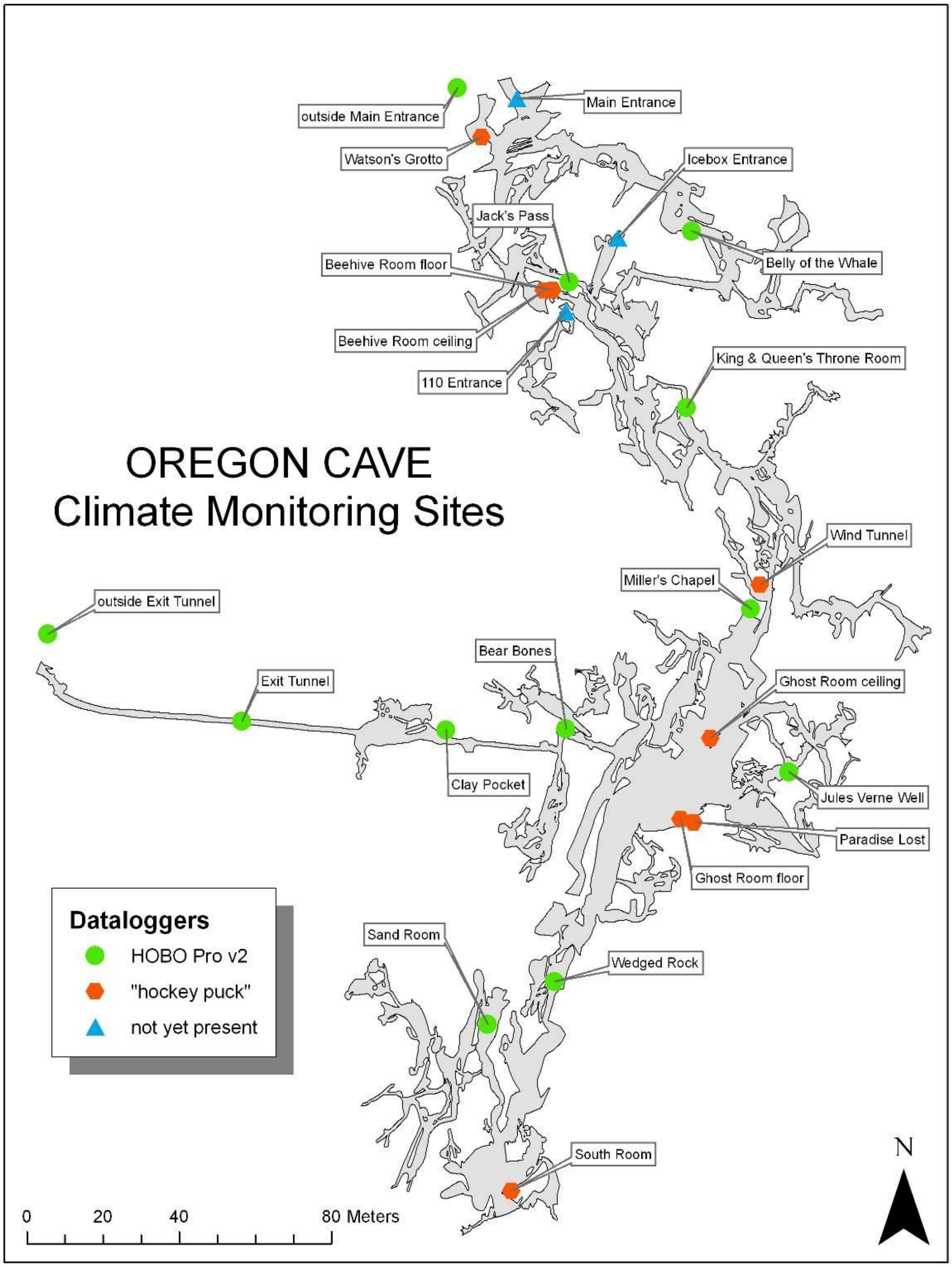


Figure 2. Monitoring sites inside Oregon Caves.

Table 1. Caves selected for monitoring and whether they were randomly chosen, or selected because of a particular resource such as visitation, ice, or bat use.

CAVE NAME	CATEGORY
L1	Bat
BALCONY CAVE	Visitor
L2	Bat
L3	Ice, Visitor
BOULEVARD CAVE	Visitor
L4	Ice
CASTLE CAVE	Random
L5	Ice
L6	Bat
L7	Ice
L8	Bat
FERN CAVE	Random
FOUR STAR CAVE	Random
GOLDEN DOME CAVE	Visitor
HOPKINS CHOCOLATE CAVE	Visitor
L9	Bat
CHOCOLATE CAVE	Visitor
L10	Random, Bat
L11	Random, Bat
LOST PINNACLE CAVE	Random
NINE INCH NAILS CAVE	Random
NIRVANA CAVE	Random
PARADISE ALLEYS	Random
L12	Random, Bat
ROLLERCOASTER CAVE	Random
SENTINEL ANNEX CAVE	Random
L13	Bat, Visitor
SILVER CAVE	Random
L14	Ice, Visitor
SOUTH LABYRINTH CAVE	Visitor
SPINY CAVE	Random
VALENTINE CAVE	Visitor

2.3 Marking Sites

The method of marking each field site is best determined by personnel on the ground and should minimize resource damage and be as inconspicuous to visitors as possible. For this reason, some general guidelines are provided in the SOP #18: Site Selection and Marking, but the exact method used can be determined by the field crew. It is important that the location of cave zones, survey/monitoring stations, and monitoring equipment (e.g., HOBO data loggers) be marked and numbered on maps (Appendix A: Cave Maps and Datasheets) and in the caves. That way, a permanent record of locations is preserved and personnel in caves can easily determine where to collect data and if equipment has been removed or disturbed. When a permanent marker is required, a small stainless steel screw can be inserted into the rock with a small wire tag affixed with the station number. Dyes, markers, and flagging were judged too ephemeral to be accurate position markers given the time scales of long-term monitoring and the high humidity of the cave environment.

For monitoring purposes, caves will be divided into three zones: Entrance, Middle, and Deep. The entrance zone is the portion of cave where surface light is visible. Where it ends, the middle zone begins and includes the next 30 m of cave passage. The deep zone can be selected subjectively by field crews according to cave morphology and resources. If a deep zone needs to be limited in size because of abundant deep cave passage, the deep zone should be about 30 m long. Some flexibility in selecting the deep zone is necessary because some caves are too long to allow monitoring of the entire cave and particular resources (such as ice deposits or bat roosts) are often not uniformly dispersed throughout the cave. Also, some caves have multiple entrances or lack true deep zones that are completely dark and distant from an entrance. In such situations, field personnel implementing the SOPs must decide on the exact placement of zones according to the cave morphology and distribution of resources. Although cave zonation can be complex, the three zones encompass the following biophysical gradient:

Entrance: Light present; active bulk air flow with surface occurs; temperature and relative humidity are most variable on daily and seasonal time scales; frequent use by opportunistic surface wildlife species that leave organic material or potentially consume cave biota.

Middle: Zone just beyond the zone of visible light; possible air exchange with exterior and use by some wildlife species; intermediate variability in temperature and relative humidity.

Deep: Light absent; minimal bulk air flow with exterior or wildlife use; most stable temperature and relative humidity and may also have “deep zone” with cold air drainage and ice or other features.

Although the zones may have internal heterogeneity for a number of reasons, this gradient in conditions is considered fundamental to understanding the cave environment. This protocol’s sampling effort is equally allocated across all zones.

SOP #18: Site Selection and Marking provides guidance on how to select/mark sites and monitoring stations within sites. SOPs give more detailed information on site selection relative to each monitored parameter.

2.4 Sampling Frequency

To meet the desired sampling regime under the current budgetary and logistical constraints, the workload and funding associated with this protocol will be divided between the parks and the KLMN. During even years (e.g., 2012, 2014…), the KLMN will provide funding to complete the work described in this protocol at both parks. In the odd years (e.g., 2013, 2015…), the parks will provide the funding to sample a subset of the parameters (bats, ice, water, visitation, and climate) described in this protocol. Table 2 provides a breakdown of the pattern as to when each parameter will be monitored during the first 5 years of implementing this protocol. Table 3 (even years) and Table 4 (odd years) provide a breakdown of when each parameter will be sampled in a given field season.

Table 2. Schedule showing when each parameter will be sampled over the first five years of implementing this protocol.

	2012	2013	2014	2015	2016
Water	X	X	X	X	X
Climate	X	X	X	X	X
Ice	X	X	X	X	X
Visitation	X	X	X	X	X
Vegetation	X		X		X
Bats	X	X	X	X	X
Scat	X		X		X
Invertebrates	X		X		X

Table 3. Schedule of when parameters will be sampled, or in the case of climate (monitored year round), when HOBO data loggers will be downloaded, during the EVEN years of implementing this protocol.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Water												
Climate	--->|				Spring download			Summer download				Winter download ---->
Ice												
Visitation	Collected year-round, entered into database by January 31 for previous calendar year											
Vegetation					One survey							
Bats	--->|										One survey -->	
Scat					One survey							
Invertebrates					One survey							

Table 4. Schedule of when parameters will be sampled, or in the case of climate (monitored year round), when HOBO data loggers will be downloaded, during the ODD years of implementing this protocol.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Climate	--->|				Spring download			Summer download				Winter download ---->
Water												
Ice												
Visitation	Collected year-round, entered into database by January 31 for previous calendar year											
Bats	--->|										One survey -->	

2.5 Statistical Power

In 2010, the KLMN, working with the staff at ORCA and LABE, implemented a pilot study to test the sampling methods outlined in this protocol (Thomas 2010). The data collected from this pilot study, along with historical data collected by the parks using similar methods, were used to determine if we will have appropriate statistical power to address our monitoring objectives. Appendix B and K provides the results of the power analysis for bat and climate monitoring completed by Dr. Kathi Irvine, Biometrician from Montana State University.

2.5.1 Climate Power Analysis

The following questions are addressed in Appendix K: Climate Power Analyses, to inform the sampling design choices for monitoring park climate variables; specifically, annual relative humidity (%) and annual temperature (Celsius):

1) How many data loggers are needed in ORCA to determine annual trends in temperature and relative humidity for the cave? How many years are needed to detect annual trends in both parameters?
2) How many caves are needed in LABE to monitor park-wide annual trends in temperature and relative humidity for each zone (deep, middle, entrance, outside)? How many years are needed to detect annual trends in both parameters?

For ORCA, the desired 80% power to detect a net change of 1% in relative humidity after 10 years will be reached around 7 years for a sample size of 23 HOBO loggers with Type 1 error of 10%. This is a relatively conservative change based on the pilot data that show there is little fluctuation in relative humidity for the 3 years of sampling. A larger net change of 5% would be detected after only 3 or so years of sampling with 80% power and 10% Type 1 error. Based on the estimated variance components, it appears that using 30 data loggers is sufficient to detect annual trends in relative humidity in the cave (Appendix K has analysis details). In terms of detecting trends in annual temperature measurements, the desired 80% power will be achieved after ~8 years of sampling for a 2.8% net change in temperature after 10 years. However, for a smaller 0.5% annual change in temperature power, there is only 60% after 20 years of sampling, and furthermore increasing to 40 HOBOs does not improve the power. Presumably, power will increase as the number of years sampled increases (Appendix K). After the power analysis was completed for 30 HOBOs, it was realized that 23 HOBOs was all that was needed to monitor climate throughout the cave.

For LABE, 80% power to detect annual trends in temperature in the middle zone will be achieved after ~12 years for a 2% annual change and 20 years for a smaller 1% change. For a 0.5% annual change, ~35 years of sampling is needed to achieve 80% power for 30 caves; increasing the number of caves to 60 does not change the power to detect trends. To increase the power to detect trends in annual temperature in the middle zone, increasing the number of years is more important than increasing the number of caves surveyed (Appendix K). For the annual trends in relative humidity within the middle zone, a similar pattern emerges in that for a small annual change of 0.1%, greater than 40 years are needed to achieve 80% power; increasing the number of caves does not substantially increase power for the smaller annual change. However, for the larger annual change of 0.5% corresponding to a net change of 9.4% in average annual relative humidity, 80% power is reached after 15 years for 30 caves.

Generally, our target sample sizes appear adequate to document substantive changes. This is due in part to the relatively low variance of the cave environments. However, it will take intensive observation over time to best determine the levels of change that are biologically significant for each of the parameters we are measuring. For instance, a 2% change in temperature is relatively small by most measures but could be very disruptive to cave arthropods and may be associated with the complete loss of cave ice. Overall, it appears that yearly sample sizes are less influential on power than the number of revisits, so our power and knowledge will increase over time.

2.5.2 Bat Power Analysis

This section investigates the power for detecting annual trends in hibernacula counts of the Townsend's Big-eared bat. Based on the targeted selection of these caves, inferring to the entire bat population across all caves in LABE is not statistically justified. Annual trends in bat counts represent only these 10-12 sampled caves; we cannot assume the same patterns hold in the un-sampled caves, as they may be categorically different for bat habitat. Given that the majority of the bats are thought to be present in these sampled caves, this is a reasonable choice for sampling bats in LABE due to budget and time constraints (section 2.2 details site selection for bat hibernacula counts).

It was determined that our ability to detect an annual trend of 3% in the median bat counts (with Type 1 error of 10% and 80% power) will be achieved after 20 years (Appendix B). This annual trend corresponds to a net change in the median bat count of 60% (quite large). However, reducing sampling to only 10 caves does not significantly affect the power to detect annual trends, so much as the number of years of data collection do (Appendix B). The power is quite sensitive to the magnitude of the year variance component; a way to increase power for detecting trends in bat counts would be to incorporate covariates that may account for this yearly variation in bat populations. Since we are collecting other parameters (Climate, Invertebrates, Visitation, Vegetation, etc.) at these caves, a long-term goal will be to determine which parameters covary with bat counts and use them to improve our power of detection.

3. Methods

3.1 Schedule

An annual calendar of events is provided in SOP #3: Scheduling. It offers scheduling guidance on necessary personnel, equipment preparation, and reporting. There is no over-arching seasonality to monitoring caves in these parks. Some activities will occur monthly, while others will be concentrated in certain seasons. The Network will perform monitoring every other year and the park staff will monitor some parameters annually, as described in SOP #3: Scheduling as well as in Tables 2 and 3 of this narrative.

The majority of monitoring will occur between April and September, when temporary employees are most available and typically fill seasonal field positions. Seasonal technicians will require training in safety and caving techniques, as well as in equipment use and data collection. SOP #2: Training provides information on the necessary qualifications, skills, and training requirements of the technicians. Hiring of seasonal workers should begin in the winter prior to each field season. During the spring, the Project Lead should develop a field schedule that specifies the upcoming training and monitoring activities, technician roles and responsibilities (SOP #2: Training and section 5.1 in this narrative), and calendar of monitoring events. Much of this scheduling can be borrowed from the calendar provided in SOP #3: Scheduling. It is important that the schedule include time for training in aspects such as cave safety, travel, and navigation, as well as in the specific SOPs they will operate under. The schedule must also allow enough flexibility to account for staff interruptions, equipment problems, and other unforeseen complications. Before the start of work, the Project Lead should provide seasonal technicians with the methods described in relevant SOPs so that they may become familiar with them. Some monitoring will occur monthly or otherwise outside of the summer season and will become the responsibility of a NPS Employee (section 5.1). SOP #3: Scheduling lists those activities, the requisite skills, and a schedule of events.

3.2 Facilities and Equipment

All activities will require supportive facilities and equipment. Equipment specific to monitoring each parameter is described in the SOPs. Basic office facilities such as storage space, a work station with a computer, and access to a server and database will be needed. Technicians will need standard caving gear, including knee and elbow pads, helmets, lights, batteries, and vehicles to travel to field sites. It is the responsibility of the Project Lead to ensure that necessary equipment is available and in working order when it is needed.

3.3 Field Methods

Specifics on field methods for monitoring each parameter are provided in the SOPs and summarized briefly in this narrative. SOP #18: Site Selection and Marking offers guidance on establishing field sites and SOP #3: Scheduling contains a calendar to assist in scheduling field activities.

3.3.1 Cave Climate

Temperature and humidity will be measured in each cave using HOBO data loggers according to the instructions in SOP #5: Climate and Appendix G: U Series HOBO Manual. At LABE, each cave will contain four HOBO data loggers. One logger will be placed in the deep, middle, and entrance zones and an additional logger will be placed outside the cave entrance. In ORCA, HOBO data loggers will be placed at 23 locations throughout the main cave and its entrance and four loggers will be placed in Blind Leads Cave following the same pattern as the LABE caves. Secure placement of climate measurement devices at valuable locations (e.g., near bat colonies, away from disturbance) is considered in SOP #5: Climate. Devices are labeled and both their location and data gathered from them are stored in a database.

3.3.2 Water Levels
In Oregon Cave, water is present in the stream as well as in seasonal pools that occasionally dry during warmer months. Water in the stream is monitored separately (Dinger et al. [Submitted]), but water levels in pools in Oregon Cave will be measured four additional times per year using bar gauges. Where a gauge cannot be permanently installed, a secure footing will be installed so the gauge can be repeatedly placed in the same location and allow consistent measurements.

ORCA also has regular water chemistry parameter monitoring through the KLMN Integrated Water Quality and Aquatic Communities Monitoring Protocol (Dinger et al. draft).

3.3.3 Ice Levels
In SOP #6: Ice, we describe monitoring of ice at caves in LABE using measurements from fixed stations above the ice as well as a method for calculating the top surface area. Survey methods provide quantitative changes in ice elevation and surface area extent and these two together can be used to gauge volume.

3.3.4 Human Visitation
Because LABE contains hundreds of caves with widely varying levels of visitation and ORCA has one main cave that is the focus of visitation, the task of monitoring visitation to caves at each park is quite different. Oregon Cave is gated and visitors purchase tickets before entering. Tickets sales are managed by the Crater Lake National History Association (CLNHA), an officially recognized National Park Service 501(c) (3) non-profit company. Data on monthly ticket sales is included in monthly reports that are sent to the NPS office in Washington DC, and copies of these reports are ideal for capturing most of the visitation to the cave. Non-ticketed visits by staff and researchers are tracked through a paper visitor log that will be implanted with the rest of these protocols (SOP #7: Visitation).

At LABE, it is more challenging to gauge human visitation because the caves are numerous (over 700 have been identified) and often un-gated. At sites that receive tourist visitors, LABE currently uses three main methods of gauging visitor numbers: visitor logs, pressure sensors, and infrared trip-beam style counters (Appendix D-F). SOP #7: Visitation provides instructions for gauging visitation and storing the information with references to the specific site and source.

3.3.5 Vegetation Monitoring
Only a handful of caves in LABE have rare fern populations. Many more caves have moss and lichen growing near their entrances, though this is also variable from one site to another. Despite providing visually impressive displays of color and texture, little is known about the importance of ferns, moss, or lichen or other plants to cave ecosystems or what factors affect their distribution and abundance. One limited study led by Tonya Vanover at Eastern Washington University found that caves with high visitor numbers showed decreased lichen and moss

coverage (though slope, elevation, and aspect were not controlled for and could affect the results) and suggests that some lichen species cannot tolerate disturbance from human visitation (Vanover et al. 2008).

Unfortunately, identifying vascular and nonvascular plant species and abundance requires specialized expertise that is beyond the ability of most cave field technicians. Therefore, vegetation will be grouped by growth form within one of three categories: vascular plants, bryophytes, or lichens. We will measure vegetative cover using the point intercept method (Elzinga et al. 2001). Two transects will be placed parallel to the cave opening and perpendicular to the passage orientation at 0.5 – 1.0 m apart. Twenty sampling points will be measured along each transect and the growth forms will be recorded when necessary. Details on how to implement this part of the protocol are provided in SOP #9: Cave Entrance Vegetation.

3.3.6 Bat Monitoring

The prescribed bat monitoring requires little specialized equipment. However, training is extremely important not only so researchers can confidently identify bats, but also to avoid disturbing them with noise, light, heat, etc., or in any way inciting unnatural behaviors (such as premature cessation of hibernation). Instructions for winter bat monitoring at nine caves in LABE (listed in Table 1) and at Oregon Cave in ORCA can be found in SOP #8: Bats. It is important to protect bat colonies by not publicizing the names of bat colony caves, so in this protocol LABE bat caves are assigned numbers that correspond with caves listed in Appendix C. Appendix C is not immediately made available to the public, but they can contact the Resource Chief at LABE to discuss and possibly obtain this information.

During the winter months (December to March), each cave will be visited once and a complete visual count of the number and type of bats using the cave to hibernate will be recorded. Each cave will be divided into zones in order to provide spatial data and two or more surveyors will record temperature data and count the number of bats per zone.

The methods described herein are aimed at small colonies (<1,000 individuals) of Townsend's Big-eared bats (*Corynorhinus townsendii*) and *Myotis* bats and assume colony fidelity to a particular area. This fidelity is not independently verified. Verification of colony identity at LABE is a priority for future investigations and, as time permits, LABE staff will survey additional caves in an effort to determine all known bat sites. If a site is found to be consistently used, it may be incorporated into this protocol assuming funding and time is available.

3.3.7 Scat and Visible Organics Monitoring

Assessing the deposition of scat using visual searches is described in SOP #10: Scat and Visible Organics. Scat monitoring tracks the deposition of rodent droppings, owl pellets, bird waste, bat guano, and any other potential source of nutrients for the cave system. Although the persistence of droppings in caves is not tested, it is generally believed they are visible for up to a year and age may be roughly gauged by the type of fungal growth. Because it is possible to count the same scat deposit in 2 successive years, it will be important to collect data for several years before drawing conclusions about scat deposition amounts or patterns. Since scat probably visibly degrades after 5 years, the "noise" from double-counting scats should have largely subsided over that time and observed patterns in scat deposition should be more reliable. This requires that methods be clear and precisely repeated across years. In addition to scat, obvious organic debris from dead animals will also be recorded as "visible organics."

Scat and visible organics monitoring will be performed using timed area searches of all cave zones between April and September every other year. Zones will match those created to monitor other parameters, such as invertebrates. A technician searches each zone, visually scanning and recording the quantity of scat and other organics.

3.3.8 Invertebrate Monitoring
Cave invertebrates are often sparsely distributed and difficult to detect, yet represent an important source of biodiversity. In SOP #11: Invertebrates, we describe a method using bait stations to increase the likelihood of detecting some species. In this SOP, the researcher places three artificial substrates with bait in each zone of the cave and then returns in 1-3 days with a quadrat to count all taxa around the bait card. Taxonomic identification guides will be developed in collaboration with regional taxonomic authorities.

4.0 Data Management

Data management for a monitoring project is a cyclic process that begins during the planning phase of a project and continues until the close-out of the season. This process is then repeated each year the project is implemented and includes planning, training, data collection and entry, validation and verification processes, documentation, distribution of project products, storage, and archiving (Mohren 2007). This section provides an overview on data handling, analysis, and report development with details on these processes located in SOPs #12-17. It is important to ensure that project personnel understand all necessary data management methodologies, including who is responsible for implementing the methods and the timelines they are expected to follow when conducting data management. SOP #15: Data Transfer, Storage, and Archive lists the target dates and responsibilities for each individual and product.

This project provides some unique data management challenges when compared to other KLMN monitoring projects because the workload and data management methods are divided between the parks and the Network. In even years, the Network will be intimately involved in the monitoring effort, however, in odd years, the park staff will take the lead role and the KLMN will play more of a supporting position. In addition, in some cases we will use data storage systems developed by the park (bat databases, TRAFx).

4.1 Preparation

From a data management perspective, preparation before field work involves examining calendars to remain aware of what data collection is upcoming and to ensure that field datasheets and databases are up to date and available, equipment has been properly calibrated, and technicians are properly trained in data management activities. The Project Lead will be in charge of initiating all field work and providing personnel the materials they need. This is best accomplished by printing out field datasheets for all caves that should visited that month. Place these sheets in a binder along with a checklist of sites that must be visited and what parameters should be measured there. If a GPS is needed to locate a cave, the Project Lead will make sure that coordinates and the GPS are available to trained technicians. A database or lookup table containing maps, descriptions, and pertinent access information for each cave, searchable by cave number or name, should be created.

4.2 Collection and Entry

Details on how to utilize the database(s) to enter data can be found in SOP #13: Data Entry. Data should be entered as soon as possible after surveys, and no more than 1 week following the field work unless prior approval is obtained from the Project Lead and Data Manager. It is the responsibility of the technicians to collect and enter most data into the initial databases. Templates for field datasheets are provided in Appendix A. Field datasheets are part of the permanent record and are discussed in SOP #15: Data Transfer, Storage, and Archive. They will be scanned and hardcopies will be stored at the KLMN Office. Datasheets should contain blank fields for each aspect technicians are expected to record (providing fields labeled with the number of each monitoring station followed by a blank line, for example), so that these blank fields prompt data collection. Different types of data are collected depending on the site, parameter, and equipment being used; however, all datasheets should contain the cave name, date, name of personnel, and a "notes" section where technicians can record any problems or observations that might provide insight to data managers and analysts. Providing clear, unambiguous field datasheets and maps is an important step in responsible data management.

4.3 Database Overview

The Klamath Network plans on maintaining a Master Cave Database which will house all the verified and validated data that are collected using this protocol (SOP #12: Cave Database). Members of this project will have read-only access to this database and can use it to conduct data summaries and use the data to develop, analyze, and synthesize reports or publications. A project database will be provided to each crew at the beginning of the field season that can be used to store all annual data collected with the exception of the LABE bat data. After validation and verification procedures have been followed, this database will be used to create summaries and conduct data analysis for annual reports. At the end of the year, the data from the project database will be uploaded to the master database for long-term storage and future analysis.

Lava Beds National Monument, working with the USDA Forest Service Pacific Southwest Research Station (PSW), has developed a database to house all historic and current bat monitoring and inventory data (the PSW Principal Investigator is Ted Weller [SOP #12: Cave Database]). It is the intention of the staff at LABE to use this database to store and analyze the bat data collected as part of this protocol. This database will be reviewed by the park and Network staff to ensure it adequately meets the data management standards set forth by the Inventory and Monitoring Program. Upon completion of the entry of seasonal bat data, a copy of this database is delivered to the KLMN and the annual data are uploaded into the Cave Master Database, which is NRDT compliant (SOP #13: Data Entry).

Individual cave numbers will form part of the numbering system that tracks all monitoring stations and in-cave equipment through the database. A lookup table or file that contains each cave name, number, and its GPS location is stored in the cave monitoring database. This database will also contain fields that identify which KLMN monitoring parameters are tracked at that cave, the numbers that identify each monitoring station, and the equipment at those stations.

4.4 Data Validation and Verification

Data will undergo two rounds of initial review by the technicians. The first review occurs in the field after each survey when the observer proofs and edits the data (SOP #13: Data Entry). This involves looking for obvious errors, typos, or missing data. Since each datasheet contains a blank field for each minimum piece of data that should be collected, there should be no blank fields (except possibly the “notes” section) without an accompanying explanation. The observer will initial the bottom of each field datasheet after it is proofread.

The second round of technician review occurs when a technician is entering the data into a database. The person entering the data can correct minor errors, such as misspellings, with a red pencil, as described in SOP #13: Data Entry. Since the database has built-in domain values, only acceptable values can be entered. Unresolved errors should be noted and forwarded to the Project Lead. Once entered into the database, the data are sent to the Project Lead for another round of reviews.

The Project Lead will review any unresolved errors identified during data entry. The Project Lead will then validate the data, checking them for completeness, integrity, and logical consistency. This is done with each individual technician's data, and those datasets are then combined into a single dataset for each survey type. Each time validation and editing occurs, the database is backed up.

The Project Lead should perform a few "spot checks" of data. Ten percent of the digital records should be compared with hardcopy datasheets. Also, the database entries should be examined for outliers or abnormal numbers that do not make sense or are atypical. If a significant amount of errors is discovered, all the datasheets and the database from that data entry event should be reviewed for accuracy. Further edits to the data should follow instructions in SOP #15: Data Transfer, Storage, and Archive.

4.5 Photographic Data

Care should be taken to distinguish data photos from incidental or opportunistic photos. Data photos are those taken for at least one of the following reasons:

1. To document a particular feature or perspective for the purpose of site relocation.
2. To capture site habitat characteristics and to indicate gross structural changes over time.
3. To document species detection or vouchers.
4. To document field crew activities during surveys and site set-up (human interest, methods, and aesthetic photos are encouraged).

It is the responsibility of the Project Lead to ensure images are properly named and stored in the correct location, along with the image metadata as described in SOP #14: Photograph Management.

4.6 Map Data

This database will contain at least two maps for each cave that receives monitoring: one General Cave Map showing natural features (including bat roosts) and infrastructure; and one Monitoring Cave Map that shows the location of monitoring stations, survey zones, and monitoring equipment (including the number of each transect or station). If a General Cave Map does not exist for a cave that receives monitoring, it will be created and the features related to monitoring should then be added to create a Monitoring Cave Map for use by monitoring personnel. Outdated versions of Monitoring Cave Maps that show the previous positions of monitoring stations and equipment will be saved in a subfolder for reference by future researchers. Existing maps will be included in their current format, and future maps should use standard methods and symbols described in Dasher (1994).

When locations of monitoring stations or transects are established, field personnel should survey to those points from established survey stations, photograph, and digitally mark those locations on a cave map. The location should also be marked and labeled in the cave whenever possible (SOP #18: Site Selection and Marking), though it is important to balance the need to mark sites with the goals of minimizing impacts and avoiding attracting the attention of tourists. The map will then be stored along with survey data and photographs in an appropriate database field. It is likely that some monitoring sites or equipment will be re-located over time and whenever this occurs, the new site must be re-surveyed, the reason for the move should be noted on the old map, and the new location should be updated on the master Monitoring Cave Map and field sheets.

4.7 Data Certification

Data certification is a benchmark in the project information management process that indicates: 1) the data are complete for the period of record; 2) they have undergone and passed the quality assurance checks; and 3) they are appropriately documented and in a condition for archiving, posting, and distributing as appropriate. Certification is not intended to imply that the data are completely free of errors or inconsistencies. Rather, it describes a formal and standardized process to track and minimize errors.

To ensure that only quality data are included in reports and other project deliverables, the data certification step is an annual requirement for all data. The Project Lead is primarily responsible for completing the Data Certification form, available on the KLMN web sites. This brief form should be submitted with the certified data according to the timeline in SOP #15: Data Transfer, Storage, and Archive.

4.8 Data Backup

Following the timeline provided in SOP #15: Data Transfer, Storage, and Archive, data and information should be submitted to the Data Manager where they will be subjected to another round of review and then stored. All data and information collected or created as part of this protocol will be stored on the KLMN server which is subject to daily, weekly, and quarterly backup process described in the Klamath Network Data Management Plan (Mohren 2007).

While the data are at the parks, appropriate measures will be taken to ensure the date and information is recoverable in the event that 1) something was accidentally deleted, 2) hardware or software fails, or 3) edits from previous versions become questionable. Once the databases are transferred to the Klamath Network Data Manager, it becomes the Network's responsibility to make certain that data are stored appropriately, distributed to the proper audience, and updated as needed.

4.9 Sensitive Information

Certain project information, for example, the specific locations of rare or threatened taxa, should not be shared outside NPS, except where a written confidentiality agreement is in place. Before preparing data in any format for sharing outside NPS, including presentations, reports, and publications, data users should refer to the guidance in SOP #16: Sensitive Data. Certain information that may convey specific locations of sensitive resources or treatments may need to be screened or redacted from public versions of products prior to release. All official Freedom of Information Act (FOIA) requests will be handled according to NPS policy. The Project Lead will work with the Data Manager and the FOIA representative(s) of the park(s) for which the request applies.

4.10 Analysis and Reporting

Details on analysis and reporting are described in SOP #17: Data Analysis and Reporting. Four types of reports will be developed as part of this monitoring effort: 1) Annual Effort Reports (in odd years), 2) Biennial Reports (in even years), 3) Resource Briefs, and 4) Analysis and

Synthesis reports. In addition to these reports, journal publications related to the objectives of this protocol are anticipated.

4.10.1 Annual Effort Report

The Annual Effort Report will be primarily an internal document prepared by designated staff members at LABE or ORCA and provided to the Project Lead to give a summary of monitoring efforts for the year, due on January 31st of the year following the sampling year (e.g., January 31, 2012, for CY 2011 efforts). This report should contain the minimal amount of metadata as described in SOP #17: Data Analysis and Reporting. In addition, it should including the following information.

1. An introduction referencing the protocol;
2. A summary of the current year's monitoring efforts including timeframe, caves visited, and what parameters were measured at each cave;
3. Any issues that were incurred;
4. Public interest highlights, if any;
5. Recommended changes to the protocol.

4.10.2 Biennial Reports

The Biennial Report will provide a summary of monitoring efforts and general findings for the preceding 2 years, due on March 31st of the year following sampling (e.g., March 31, 2013, for calendar year 2011-12 efforts). The person writing the annual report needs to have a good command of basic computer software (including graphical data display), have spent a significant amount of time performing the monitoring of at least half of the different parameters, and have consulted with other data collectors and upper-level resource managers about the discussion and conclusions. This report will include the following:

1. Abstract. Include a summary of findings as well as highlights of the conclusions.
2. Introduction. A short narrative that places the monitoring years in context of all monitoring in the park.
3. Methods. A summary of the survey effort if it differed from protocols, or reference to protocols that were followed.
4. Results. This section can be organized by site or if another structure is desired, it may be adopted.
5. Discussion. This will not be extensive but can offer interesting or anomalous findings from the results.
6. Logistical Challenges, Protocol Review Recommendations, and Expected Equipment Needs.
7. Key Accomplishments and Seasonal Highlights.

4.10.3 Resource Briefs

Resource briefs are one to two page summaries about the current monitoring effort. These reports are designed to quickly inform resource manages about the work that has been completed and any significant results related to this effort. In addition, these reports are written in a non-technical manner so they can be delivered to all park staff who may be interested in our efforts. Resource briefs should follow the template developed by the KLMN and can be developed by park or Network staff who are familiar with this project.

4.10.4 Analysis and Synthesis Reports

Analysis and Synthesis reports will be completed every fourth year, due on March 31st of the following year (e.g., final draft of 2016 Analysis and Synthesis report will be due March 31, 2017). The Analysis and Synthesis reports will follow standard scientific format (abstract, introduction, methods, analysis, results, discussion, literature cited), but will vary in length and focus depending upon the core topic addressed. SOP #17: Data Analysis and Reporting provides the details related to each Analysis and Synthesis report; however, a brief description is provided below.

Analysis and Synthesis Report 1: A Gradient Analysis and Typology of Cave Environments and Communities in Lava Beds and Oregon Caves National Monuments: After 4 years of monitoring data have been collected at LABE and ORCA, Analysis and Synthesis Report 1 will summarize the general patterns and types of cave environments and communities in the parks. The specific parameters to be analyzed include cave microclimate, ice and water resources, visitation patterns, cave entrance vegetation, cave invertebrates, visible organics, and bats. To the degree possible, the efforts will attempt to elucidate spatial patterns in each of the parameters across each park sampling frame, and identify general types of cave environments and biological communities found. We expect the report will have broad relevance to general management and interpretive planning at each park, as well as general interest to the public.

Analysis and Synthesis Report 2: Status, Trends, and Dynamics in Cave Environmental Conditions: This Analysis and Synthesis report will analyze and synthesize cave environmental data from the first 8 years of monitoring, augmented with comparisons to longer term time measurements undertaken by the parks. Specific parameters will include visitation, cave microclimate, ice, water, water quality and flow parameters collected under Water Quality Sampling (Klamath Streams Protocol; Dinger et al. [Submitted]) for Cave Creek at ORCA, and inputs of mineral nutrients from visible organics. Our general aim will be to summarize the human stressors and abiotic environments of caves in this report.

Analysis and Synthesis Report 3: Status, Trends, and Dynamics in Cave Communities: This Analysis and Synthesis report will summarize and analyze cave community data from the first 12 years of monitoring, with comparisons to longer term time series based on park sampling as feasible (e.g., for bats). Specific parameters will include cave invertebrates, visible organics, bats, and cave entrance vegetation. Our general aim in this report will be to summarize the status, trends, and dynamics in the diversity, distribution, and compositional changes in cave biological communities over time.

4.10.5 Report Format

Reports will be formatted using the NPS Natural Resource Publications templates, which are pre-formatted Microsoft Word template documents based on current NPS formatting. Biennial reports will be formatted using the Natural Resource Data Series template while Analysis and Synthesis reports and other peer-reviewed technical reports will be formatted using the Natural Resource Technical Report template. These templates and documentation of the NPS publication standards are available at: http://www.nature.nps.gov/publications/NRPM/index.cfm.

In addition, a standardized template for the annual effort report will be developed in 2010 that will be used for the annual effort reports.

5.0 Personnel Requirements and Training

5.1 Roles and Responsibilities

These protocols were designed so they can be repeated by changing staff across many years while at the same time collecting data in a consistent manner. A Project Lead, who is a Network employee, will be in charge of overall project oversight. A single park-based GS-9 Cave Specialist will serve as the Field Lead for all activities in both parks. This person will oversee the scheduling, hiring, training, and ensuring that SOPs are followed. For many tasks, this will involve a Field Crew Leader at a GS-7 level that manages technicians. Most of the activities covered in the SOPs do not require extensive training or experience and can be completed by well trained seasonal technicians. For some field operations, such as bat monitoring where sensitive resources are involved, a senior resource technician is necessary to act as a crew leader. SOPs provide more detail on what will be expected of field personnel.

5.2 Qualifications, Hiring, and Training

Seasonal workers or park staff should be able to carry out the instructions in the SOPs. The exception concerns the generation of reports. For annual effort reports, a staff member with highly developed written communication skills and firsthand knowledge of the caves and monitoring parameters is necessary. For the Biennial and Analysis and Synthesis reports, the author(s) must collectively possess a familiarity with the caves, parks, and monitored parameters as well as some knowledge of biostatistics using univariate and multivariate analyses.

Seasonal field technicians should have university-level knowledge or experience in the natural sciences, geography, or environmental resource management fields. They should be in good physical condition and able to safely traverse uneven ground and negotiate all caves where work will be performed. They should also be able to work independently with little direct supervision and must be comfortable working in caves and remote areas of the park. It is extremely important that they understand how to collect and record accurate data for scientific investigations and know when to ask for assistance when needed. This is best demonstrated by some research or field work experience, but can also be demonstrated by coursework that requires data collection and management.

Hiring summer seasonal workers should begin in December of each year, when possible. Hiring of seasonal employees should follow standard procedures for federal employment. It is also possible to supplement the field crew with staff from regional universities and the Student Conservation Association, as needed.

Once technicians are hired, it is the responsibility of the Project Lead to send them the protocol, which they will be asked to follow. At this time, it is also advisable to provide information on the park itself and living and working conditions, including hours, residency information, rules/restrictions, and even area maps. This information will help these technicians plan their stay and understand what is expected of them. They may have basic questions and concerns about day to day operations and living, managing workloads, and conducting themselves in a professional field environment. Technicians generally arrive at the park 1 to 2 weeks before they are expected to begin their seasonal monitoring duties. This orientation period will be devoted to an introduction to the park and its operations and to training. All seasonal workers in the parks generally receive training in safe caving techniques, radio communication, travel across country, minimizing impacts, navigating in the parks (including reading cave maps and using GPS), and dealing with emergencies.

5.3 Safety

Safety is the first priority. Anyone entering a cave should have at least three independent sources of light and someone on the surface should be aware of where field personnel are planning on going each day. Field crews should be trained on park check-in and check-out processes and it is up to the Project Lead to make certain field crew members are safely out of the caves by the end of the day. It will be especially important to train seasonal personnel in safe caving techniques in addition to the more typical aspects of safe field work. A clear plan on whom to contact in the case of a medical emergency should be described to all field personnel. More safety information is available in Appendix L. Job Hazard Analysis.

5.4 Workload

The annual workload is laid out in SOP #3: Scheduling, and individual SOPs detail the work involved in monitoring each environmental parameter. It is anticipated that hiring will begin in December, training in April or May, and field work will begin in May or June and run until September for even years. Year-round park staff will be used to implement the monitoring of subsample of the parameters which should be collected following the schedule in SOP #3.

During the field season, data management is as important as data collection and should follow the guidelines laid out in SOPs #13-17. The KLMN Data Manager should be in close contact with the Project Lead regarding data management issues. The Project Lead and some park staff should be familiar with the database and architecture of the data storage program(s) that will house information collected under these protocols. It is important that multiple park staff be familiar with the data management procedures so that they can answer questions from seasonal technicians and so that someone at the park can handle data management in the event of staff turnover. Basic data entry will often be performed by seasonal technicians. They should be shown what to do and provided with written instructions to reference. It is the duty of the Project Lead to provide these instructions and ensure they are properly trained.

6.0 Operational Requirements

6.1 Annual Activities and Schedule

Activities related to cave monitoring will take place throughout the year, though the majority will be concentrated between April and September when the parks receive the most visitors and seasonal technicians are the most available. Initially, park staff will have to create datasheets specific to each cave and parameter that is sampled; create cave maps and survey zones; establish sampling stations; and install climate measuring devices, cave logs, and visitor counters. Regular maintenance of equipment, hiring and training, and data collection will all be performed and are described in various SOPs as well as in Tables 3 and 4. A calendar of events is provided in SOP #3: Scheduling to aid in planning upcoming activities.

Data from the caves will be recorded on hardcopy field datasheets (templates are provided in Appendix A), validated while on-site, and then entered into the database program according to SOP #13: Data Entry. Once entered, the data will be validated according to SOP #15: Data Transfer, Storage, and Archive. Once validated, the data will be reported according to instructions in SOP #17: Data Analysis and Reporting, and archived.

Annual data reports, Biennial Reports, Analysis and Synthesis reports, and Resource Briefs will be the primary reporting tools used for disseminating the findings from this protocol. Report preparation occurs after data are collected, entered, validated and certified. Instructions on data reporting are included in SOP #17: Data Analysis and Reporting. To make reporting as streamlined as possible, the authors of this monitoring protocol will work with the KLMN data manager to design a database that lends itself to easily searching, analyzing, and reporting data in the format that reports are likely to take. Reports will most likely be generated by NPS staff who should be trained in database use and be familiar with related SOPs.

6.2 Facilities and Special Tools

This project does not require any unusual facilities; however, some specialized equipment (such as data loggers) will be necessary. Equipment specific to each parameter is listed in the respective SOP. Access to computers and servers, some basic lab equipment, and storage for equipment will be necessary. Traditional caving gear will also be required, as will vehicles to reach field sites. Housing for field crews might also be necessary. The Project Lead will coordinate with the parks to ensure that all equipment needs are met at least 1 month before scheduled sampling occurs.

6.3 Budget Considerations

LABE resource management staff estimated that the equivalent of 0.4 FTE (full-time employee) could be allocated annually towards implementation of the cave monitoring protocol. This time expenditure translates to about 104 days of work.

Approximately two-thirds (66.7%) of the funding for the Field Lead will go to LABE and the remaining one-third will be devoted to ORCA. Every other year, on even years, monitoring efforts will be supplemented with Klamath Network funding and additional staff. During these years, the overall workload will be greater, as all SOPs will be implemented, whereas three of the SOPs (Cave Entrance Vegetation, Scat and Visible Organics, and Invertebrates) will not be implemented in odd years. During odd years, park-based staff will implement selected elements of the protocol, fully funded by the appropriate park. The funding commitments for staffing for the two parks will be approximately $30-$33k for LABE and $15-16.5k for ORCA in each of the odd years over the next 6 years. In even years, monitoring efforts will be supplemented with Klamath Network funding and additional staff. Projected budget allocations by KLMN staff estimate that $67-$76k will be available to support park-based and seasonal cave monitoring staff in even years (Table 5). This amount should be sufficient to fund the equivalent of at least 0.8 FTE split between a GS-5 seasonal and a GS-7 term or permanent, which translates to about 208 days of work.

Due to the training needs involved with preparing seasonal employees to implement monitoring protocols, permanent or term LABE or ORCA staff would be required to invest considerable time towards Network monitoring activities. For this reason, the Network will fund some pay periods of the GS-7 and GS-9 Cave Specialist term positions at LABE and ORCA in addition to funding seasonal hires. Furthermore, divulging sensitive cave locations and resources to seasonal staff should be minimized, thus funding for such activities will be provided for long-term employees rather than seasonal hires. Table 5 summarizes projected staff costs for implementing the monitoring program, from FY2012 to FY 2016.

Table 5. Projected costs for implementing the Cave Protocol, FY2012-2016.

	Position	Pay Scale and Pay Periods (even years)	Pay Scale and Pay Periods (odd years)	Salary and Benefits per PP (FY2012 Projected)	2012	2013	2014	2015	2016
Income									
KLMN Caves Budget Allocation					$67,334	$0	$71,434	$0	$75,785
KLMN Base					$16,971	$5,591	$18,668	$6,150	$20,535
LABE Base						$30,000		$33,000	
ORCA Base						$15,000		$16,500	
Total Income					**$84,305**	**$50,591**	**$90,102**	**$55,650**	**$96,320**
Expenses									
KLMN Personnel	Project Lead	GS-12 (3.0 pp)	GS-12 (0.5 pp)	$3,993	$11,979	$2,096	$13,177	$2,306	$14,495
	Data Manager	GS-11 (1.5 pp)	GS-11 (1.0 pp)	$3,328	$4,992	$3,494	$5,491	$3,844	$6,040
KLMN Staff Subtotal					***$16,971***	***$5,591***	***$18,668***	***$6,150***	***$20,535***
LABE Personnel	Cave Specialist	GS-9 (2 pp)	GS-9 (5 pp)	$2,753	$5,506	$14,453	$6,057	$15,899	$6,662
	Field Leader	GS-7 (8 pp)	GS-7 (5 pp)	$2,601	$20,808	$13,655	$22,889	$15,021	$25,178
	Field Crew	GS-5 (8 pp)		$1,533	$12,264	$0	$13,490	$0	$14,839
LABE Staff Subtotal					***$38,578***	***$28,109***	***$42,436***	***$30,919***	***$46,679***
ORCA Personnel	Field Leader	GS-7 (4 pp)	GS-7 (3 pp)	$2,601	$5,202	$8,193	$5,722	$9,012	$6,294
	Field Crew	GS-5 (4 pp)	GS-5 (3 pp)	$1,533	$12,264	$4,829	$13,490	$5,312	$14,839
ORCA Staff Subtotal					***$17,466***	***$13,022***	***$19,213***	***$14,324***	***$21,134***
Other									
	Field Equipment			$2,500	$2,500		$2,652		$2,814
	Vehicles			$3,500	$3,500	$2,000	$3,713	$2,200	$3,939
Other Expenses					***$6,000***	***$2,000***	***$6,365***	***$2,200***	***$6,753***
Total Expenses					**$79,015**	**$48,721**	**$86,682**	**$53,593**	**$95,101**
KLMN Contribution					***$79,015***	***$5,591***	***$86,682***	***$6,150***	***$95,101***
LABE Contribution						***$28,109***		***$30,919***	
ORCA Contribution						***$13,022***		***$14,324***	
Balance					**$5,290**	**$1,869**	**$3,421**	**$2,056**	**$1,219**

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